

The status of the Heath Fritillary butterfly *Mellicta athalia* (ROTTEMBURG, 1775) in the forest of Fontainebleau, Île-de-France: on the beneficial effect of the extratropical windstorms Lothar and Martin in December 1999

(Lepidoptera, Nymphalidae)

by

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Abstract: In modern landscapes, numerous taxa are threatened by the destruction and fragmentation of their habitat. Several butterfly species have become restricted to relatively small or completely isolated patches of habitat. Nevertheless, these fragmented habitats are usually not completely isolated from one another and many species can persist in a regional network of suitable habitat, connected via migration, as a metapopulation. The long-term survival of such a metapopulation is dependent on a balance between local extinction and (re)colonisation.

The metapopulation theory predicts that the rates of colonisation increase as habitat patches become larger and better connected via migratory corridors. To promote species re-expansion through the landscape, networks of suitable habitat patches are required in close proximity to existing refuge populations. This can be achieved by management efforts of habitats.

In this paper, we document rapid metapopulation recovery and range re-expansion of a species after the two windstorms Lothar and Martin swept through France in December 1999. The effect of the storms was strong and negatively impacted the economy, but created natural clearings which led to a spectacular Heath Fritillary expansion in the Île-de-France region where *Mellicta athalia* (ROTT.) is red-listed by law. This study illustrates that a metapopulation can naturally re-occupy lost habitat. We also emphasize the need to maintain coppice for population maintenance and (re)expansion in suitable habitats.

Zusammenfassung: In der modernen, anthropogen umgestalteten Landschaft sind viele Arten durch die Zerstörung und Verinselung ihrer Habitate bedroht. Etliche Arten leben nur noch in kleinen oder völlig isolierten Lebensräumen. Dennoch scheinen diese Biotopfragmente nicht völlig voneinander isoliert zu sein, da in einem regionalen Netzwerk bewohnbarer Habitate diese durch Zu- und Abwanderung der Arten verbunden sind und die betreffenden Arten als Metapopulation weiter existieren können. Das dauerhafte Überleben einer derartigen Metapopulation hängt von dem Gleichgewicht zwischen dem lokalen Erlöschen und der (Rück-)Besiedelung einer Lebensraumparzelle.

Die Metapopulationstheorie besagt, daß eine Besiedelung um so rascher erfolgen kann, je größer die einzelnen Habitate sind und je besser diese durch Wanderkorridore vernetzt sind. Um eine Wiederausbreitung von Arten innerhalb eines Gebietes zu fördern, ist ein Netzwerk passender Biotope erforderlich, das in enger Nachbarschaft zu refugialen Populationen liegt.

In dieser Arbeit dokumentieren wir die rasche Erholung und Arealrückgewinnung der Metapopulation einer Art, nachdem zwei Stürme, Lothar und Martin, im Dezember 1999 über Frankreich hinweg gefegt war. Die Auswirkungen der Stürme waren heftig und verursachten große

ökonomische Schäden. Auf der anderen Seite sorgten die Stürme für natürliche Schnesen, die zu einer spektakulären Expansion von *Mellicta athalia* (ROTT.) in der Île-de-France-Region führte, einer Art, die in Frankreich gesetzlich geschützt ist. Diese Studien zeigen, daß eine Metapopulation, auf natürlichem Weg, verlorenes Terrain zurück gewinnen kann. Ferner fordern wir mit Nachdruck die Notwendigkeit zum Erhalt von Populationsgeflechten, damit diese geschützt werden und die Möglichkeit zur (Rück-)Besiedelung geeigneter Lebensräume verschafft werden kann.

Introduction: Habitat loss and the resulting fragmentation of the landscape are considered as the main threats to biodiversity (WILCOX & MURPHY, 1985; SAUNDERS et al., 1991 and CAUGHEY, 1994). The prediction of species' survival in isolated habitat and fragmented landscapes is a huge challenge for conservation biology (FAHRING & MERRIAM, 1994). Species' extinction in such landscapes clearly depends on potential dispersal rates (FAHRING, 2002); we can therefore expect that strong selective pressure on dispersal is also associated with habitat fragmentation.

Many butterfly species have severely declined in western European countries in recent decades and in almost all types of habitats (THOMAS et al., 1992; WARREN, 1992).

This process of species' loss is mainly due to man-induced destruction and fragmentation of suitable habitats, leading to isolation of local populations. Past efforts to reduce extinctions by maintaining local nature reserves have not always succeeded in conserving threatened species at a regional scale (THOMAS, 1984). The metapopulation concept, coined by LEVINS (1969), has been developed as a predictive tool of population survival in a fragmented landscape (GILPIN & HANSKI, 1991; HANSKI & GILPIN, 1997). In such a system, each local population has its own probability of extinction and (re)colonisation. Occupied patches within the landscape are connected by occasional migration. Most butterflies are closely related to particular habitats for their larval development and large scale movement between sites was thought to be very rare; such species were expected to display closed and isolated populations (WARREN, 1992).

Population structure in melitaeines: The structure of melitaeine populations was already noted as being of a patchy nature (FORD & FORD, 1930; EHRLICH, 1961). This structure is made all the more complex by the sedentary behaviour of individuals within their habitat patches (EHRLICH, 1961, 1965; WARREN, 1987a, 1987b, 1987c; HARRISON, 1989; HANSKI et al., 1994). A consequence of this sedentary behaviour is that populations fluctuate in size independently from each other (EHRLICH et al., 1975; HANSKI et al., 1995a). Sometimes populations go extinct, but are balanced by occasional colonisations of those empty patches (HANSKI et al., 1995a).

The population structure described above is known as a metapopulation (LEVINS, 1969).

All known and studied melitaeine species show a fragmented population structure: *Euphydryas editha* (BOISDUVAL, 1852) (EHRLICH et al., 1975 ; THOMAS et al., 1996), *E. chalcedona* (DOUBLE-DAY, [1847] (BROWN and EHRLICH, 1980), *E. gillettii* (BARNES, 1897) (DEBINSKI, 1994), *E. aurinia* (ROTTEMBURG, 1775) (WARREN, 1994; LEWIS & HURFORD, 1997), *Melitaea cinxia* (LINNAEUS, 1758) (HANSKI et al., 1994, 1995a, 1995b, 1996), *M. didyma* (ESPER, 1777) (VOGEL, 1996; VOGEL & JOHANNESEN, 1996) and *M. athalia* (ROTT.) (WARREN, 1987a, 1987b, 1987c, 1991).

Movements of individuals: As with many other species, such as those belonging to the genus *Parthenos* (DESHAMPS-COTTIN et al., 1999; MERIT & MERIT, 2006), the movements of melitaeine butterflies have been much investigated using mark–recapture studies, beginning with the initial works of EHRLICH (1961). Most studies have found the melitaeine species to be sedentary, regardless of how common they are (EHRLICH, 1965; SCHRIER et al., 1976; CULLENWARD et al., 1979; BROWN & EHRLICH, 1980; WARREN, 1987; HANSKI et al., 1994; VOGEL, 1996; MUNGUIRA et al., 1997). Because of this sedentary behaviour, all those butterflies' populations have been named 'closed populations' (THOMAS, 1984; WARREN, 1992). This behaviour within the melitaeine group classifies it to a metapopulation structure. However, despite their sedentary behaviour, movements of more than a kilometre have been recorded in all main studied species (EHRLICH et al., 1975; HANSKI et al., 1994; HANSKI and KUSSAARI, 1995). Such movements may occur later in the season resulting in a failure of the species to colonise the newly visited zone. The main reason for the failure being the fact that such late migration generally occurs towards the end of the flight season, thus the newly hatched larvae face senescence of their host plant before they can reach their diapause size. In most species the occasional long-distance migrant tends to lead to less genetic differentiation in local populations (WAHLBERG, 2000). This has been observed in many melitaeines (BRUSSARD & VAWTER, 1975; MCKECHNIE et al., 1975; VAWTER & BRUSSARD, 1975; BRUSSARD et al., 1989; DEBINSKI, 1994; JOHANNESSEN et al., 1996). Long-distance migration has also important impacts on metapopulation dynamics. For instance, *M. cinxia* (L.) has been observed to colonise empty patches up to 5 km from the nearest occupied patches (MÉRIT et al., 2003). Long-distance migration can help stabilize metapopulation dynamics and decrease the genetic drift.

Factors affecting immigration have not been studied in great detail. KUSSAARI et al. (1996) found that butterflies were more likely to immigrate into larger patches close to existing populations (e. g. in *M. cinxia* metapopulations, where larger and less isolated patches are more likely to be colonised; HANSKI et al., 1995a).

Mellicta athalia (ROTT.) lives in colonies known as metapopulations. A colony is defined as a group of individuals that occurs in a discrete area and is separated from other groups by at least 300 m of apparently unsuitable habitat, which probably restricts the free interchange of individuals.

The colony sizes are:

Large: over 200 adults during the peak flight period.

Medium: 20–200 adults at peak.

Small: less than 20 adults at peak.

Biology of *Mellicta athalia* (ROTT.): The species occurs from Western Europe through Russia and Asia to Japan. In Southern France it is extremely widespread and breeds in unimproved hay meadows and pastures (WARREN, 1985c). It is endangered in the Netherlands (GERAEDTS, 1986; VERSPUI & VISSER, 1992) and has declined severely in many countries in Northern Europe, including Belgium (VERSTRAETEN, 1985), Northern France and parts of Western Germany (WARREN, 1992). This species with strict ecological requirements has been listed in red data books at the country or district level. For instance, in the Île-de-France area, the Heath Fritillary, *Mellicta athalia* (ROTT.) is listed in the Île-de-France Red Data Book (Arrêté du 22 Juillet 1993, NOR: ENVN9320306A).

Life cycle: The Heath Fritillary lives in discrete colonies in relatively warm and sunny habitats, with topological shelter or shelter provided by shrubs or trees, where the food plants grow in abundance among an otherwise sparse ground flora on poor, well drained soils. It flies from mid-May until mid-July in northern France as a single brood. In the south of France there is a second generation characterising *M. a. celadussa* (ROTTEMBURG, 1775). The eggs are laid typically in batches of between 100–150, close to the ground on the underside of a leaf immediately next to the foodplant, and only rarely on the foodplant itself. The larvae feed in a small web until L2-L3, and disperse into smaller groups at L3. These groups overwinter. The larvae emerge again in March or April and feed sporadically between lengthy bouts of basking on dead leaves or twigs. They pupate within the leaf litter, often within curled-up dead leaves.

Foodplants: The Heath Fritillary occurs in three types of habitat in northern France:

- Coppiced/newly-felled woodland where it breeds solely on Common Cow-Wheat (*Melampyrum pratense*);
Unimproved grassland with abundant food plants Ribwort Plantain (*Plantago lanceolata*) and Germanander Speedwell (*Veronica chamaedrys*)
- Sheltered heathland combs where its primary host is Common Cow-Wheat and its occasional second host plant is Foxglove (*Digitalis purpurea*) (WARREN et al., 1984; WARREN, 1987a).

The first two of these habitats deteriorate rapidly without appropriate management and in woodland the habitat often remains suitable only for up to three years after felling (possibly 10 years in certain conifer habitats) (BARNETT & WARREN, 1995 ; WARREN, 1987c, 1992).

In the forest of Bière (namely forest of Fontainebleau) - and especially in the studied areas, the Heath Fritillary inhabits mainly the first type of habitat, i. e. coppiced/ new-felled woodland in the Plaine de Chanfroy and in the Plaine de Macherin and the second type of habitat, i. e. unimproved grassland in the La Feuillardière.

The conservation requirements of the Heath Fritillary are fairly well understood in woodland. adults are extremely sedentary and even small strips of unsuitable vegetation represent major barriers to dispersal. The species requires the creation of new clearings on a regular basis which are located close to occupied habitat so that colonisation can occur rapidly after clearance. Grassland habitats have been successfully maintained by rotational cutting, every 2-5 years. The major threats to the butterfly are thus the lack of appropriate management in the habitats where colonies survive. Continuation of nature reserve management is important to the continual survival of several woodland and grassland colonies. There is a long term threat from isolation and fragmentation of habitats and viability of populations, and potentially a minor threat from collectors (WARREN et al., 1984; ULRICH, 1985; BARNETT & WARREN, 1995).

Ecology of the Heath Fritillary per type of habitat (BARNETT & WARREN, 1995)

Coppice/ Newly-Felled Woodland: The Heath Fritillary's most characteristic habitat is newly-coppiced and nearby deciduous woodland where it breeds solely on the Common Cow-Wheat (*Melampyrum pratense*). This annual plant is largely confined to acid soils and is semi-parasitic on the roots of certain deciduous trees and probably a few grasses (CRESSEY, 1987). It is usually rare or absent under dense woodland canopies but often becomes abundant in the year or two

following clearance. Such conditions provide a particularly warm micro-climate, but are short-lived as the vegetation regrows making the host plant too shaded for oviposition.

Unimproved Grassland: The second biotope consists of unimproved grassland where a different host plant, Ribwort Plantain (*Plantago lanceolata*) is abundant (5-20% ground cover). Several other plants are also eaten, including Germaner Speedwell (*Veronica chamaedrys*) and a secondary host plant the Foxglove (*Digitalis purpurea*), which is sometimes used by postdiapause larvae. Suitable conditions occur only in fairly short (less than 20 cm tall), herb-rich vegetation that is not dominated by rank grasses. Such habitats have been provided for a few years by the abandonment of flower-rich hay-meadows usually prior to afforestation. In contrast to parts of Continental Europe, the Heath Fritillary does not seem capable of surviving in British hay-meadows that are cut during the summer (WARREN, 1985). Suitable *Plantago*-rich biotopes have occasionally developed on disturbed ground such as disused railway lines or even abandoned market garden allotments on steep slopes. All these biotopes soon become too overgrown for breeding if left unmanaged and few remain suitable for more than 10-15 years (BARNETT & WARREN, 1995; WARREN, 1992).

Lothar and Martin Windstorms – 26 & 28 December 1999: Two extratropical cyclones: Lothar and Martin affected western Europe respectively on December 26 and 28, 1999. The windfields from the two storms covered more than half of France and extended into Switzerland and Germany (col. pl. 28: 1). The two storms propagated from separate Atlantic depressions loaded with warm air, which strengthened both as they made landfall and met with a cold air mass (ABRAHAM et al., 2000).

Temperature contrasts caused extreme turbulence along the weather front, creating the first storm (Extratropical cyclone “Lothar”), which first developed east of Newfoundland early on December 25. The storm was swept along by an exceptional jet stream early in the morning of the 26th, at forward speeds of up to 130 km/h. As Lothar reached the coast of northern France, the speed of the storm slowed to 97 km/h and the system began a rapid phase of intensification - the pressure falling an almost unprecedented 32 millibars (mb) in 8 hours, reaching 960 mb as the storm hit Paris. Although Windstorm Lothar was only 300 km in diameter, far smaller than most extratropical cyclones, the dramatic intensification resulted in internal pressure gradients comparable to those found in a strong Category 2 hurricane. Unlike a hurricane, however, the system did not weaken after landfall, but continued to intensify as it travelled inland. High winds were located in a 150-km wide band immediately to the south of the track. The winds on the ground reached more than 180 km/h on the coast, and inland up to 172 km/h at Orly Airport to the south of Paris, where the storm was at its most intense. Gusts of over 210 km per hour were recorded at 4am in Brittany, with similar windspeeds recorded hours later in the Black Forest in Germany, hundreds of kilometres away. As the storm moved East through Europe, record windspeeds (gusts of over 241 km/h recorded in Zürich and over 170 km/h in Paris), gave rise to substantial damage, imposition of a state of emergency in Paris and the deployment of thousands of troops (col. pl. 28: 2).

Even before Lothar had dissipated, a new westerly moving disturbance was developing close to where Lothar originated. This second storm (Extratropical cyclone “Martin”) issuing from a similar but different Atlantic system then hit the French west coast the next day. Tracking 200 km south of the first storm, Windstorm Martin reached its lowest recorded pressure (964 mb) and highest windspeeds as it crossed the French coast on the evening of December 27.

The windspeeds from the second storm, Martin, were generally not as high as those from Lothar.

The storm, however, carried a lot of moisture, and damage stemmed not only from windspeeds but also from rain and subsequent flooding. On the night of December 24–25, 1999, a vast counter clockwise circulation associated with a depression over England brought Arctic air from north-eastern Greenland down to interact with tropical air circulating around the Bermuda High. Lothar developed along the cold front where these air masses met. The location and strength of the jet stream that ran above this front turned a small vortex disturbance into the most intense cyclonic depression to make landfall in western Europe in a decade. There was a marked boundary to the south, with warm moist air raised into the upper atmosphere by the intense convective activity over the Caribbean during December. At 9-km elevation on Christmas Day, the jet stream reached 400 km/h, evidenced by Christmas Day flights from New York to London that arrived 90 minutes early. Approximately 24 hours before the storm hit France, Météo-France issued a warning of a strong storm with the correct path, but two hours before the storm hit Paris, inland windspeeds were still predicted to be between 90–130 km/h, rather than the 125–175 km/h range actually experienced. The system affected most of Southern Europe, generating windspeeds greater than 170 km/h in Northern Spain (Asters); and windspeeds from 200 km/h in Aoste (Italy) to 150 km/h in Sicily, which was effectively cut off from the rest of the World by high tides and strong winds (col. pl. 28: 3).

The highest intensity of the storm Lothar in the Île-de-France (Figure 2) was in the vicinity of Orly, with high speed winds in the forest of Fontainebleau (40 km south from Orly) and in the vicinity of Melun (GODARD, 2005). A large number of vineyards, fruit trees and other trees, often the older ones, were uprooted. Numerous crops were ruined by the diluvial floods, and the majority of agricultural greenhouses were destroyed (DOLAT et al., 2001). Among the most vulnerable to wind damage were Pine trees, still with their leaves during winter time, and Poplar growing on heavy wet soils. Thus, some parts of the forest of Fontainebleau were relatively preserved as opposed to the western or northern areas of the forest. The area of Arbonne-la-Forêt and St Herem had a huge loss of Pines, Poplars, Oaks and Sequoias (in Plaine de la Solle, Plaine de Chanfroy, Plaine des Pins, La Gorge aux Loups and mainly in forest areas No 178, 82, 83, 562) (GODARD, 2005).

“Rediscovery” of *M. athalia* (ROTT.) in Chanfroy and dispersal into small colonies: The extinction of local populations of *M. athalia* (ROTT.) in the forest of Fontainebleau is mainly due to the extensive artificial afforestation. The forest is managed by the Office National de la Forêt (National Forest Management) which has the main interest in afforesting, nurseries and growing trees for selling purposes. The main effect of the windstorms was to create openings in closed parts of the forest in Plaine de Chanfroy.

In 2001, two years after the windstorms Lothar and Martin, the first specimen of *M. athalia* (ROTT.) was rediscovered after years of disappearance (LUQUET, 1997; MÉRIT & MÉRIT, 1997; GIBEAUX, 1998; Mérit, 2001; LERAUT, 2001). The initial discovery of *M. athalia* (ROTT.) was in site c1 (fig. 4 and Table 1) (MÉRIT et al., 2003) whilst we were monitoring the site for the STERF (French Butterfly Monitoring Scheme; MANIL et al., 2005). We observed a local dispersal the following year in site c2. The peak of dispersal was observed in 2003 with newly colonised sites c3 and c4. The number of specimens was monitored according to the transects method (MOORE, 1975). In 2004, the number of specimens seen in Chanfroy was 20% less, but new sites were (re) colonised in La Feuillardiére (f1) and in Macherin (m1 and m2) from ca. 1.7 km and 4.5 km of the initial rediscovery in Chanfroy respectively (fig. 5; col. pl. 4).

Year	Sites ID	1999	2000	2001	2002	2003	2004	2005	2006	2007
Chanfroy	c1	0	0	36	84	147	116	78	66	57
	c2	0	0	0	18	55	44	32	35	15
	c3	0	0	0	0	13	15	8	10	11
	c4	0	0	0	0	10	8	5	7	9
	Total	0	0	36	102	225	183	123	118	92
Macherin	m1	0	0	0	0	0	2	2	5	3
	m2	0	0	0	0	0	1	2	4	3
	m3	0	0	0	0	0	0	2	3	2
	Total	0	0	0	0	0	3	6	12	8
La Feuillardière	f1	0	0	0	0	0	2	0	0	0
	Total	0	0	0	0	0	2	0	0	0
	TOTAL	0	0	36	102	225	188	129	130	100

Table 1: *Mellicta athalia* (ROTTENBURG, 1775) rediscovery and (re)colonisation in Chanfroy, Macherin and La Feuillardière in the forest of Fontainebleau.

Site c1 is composed of small clearings whilst sites c2, 3 and 4 are mainly coppice on open woodland. Sites m1, 2 and m3 are open woodlands and coppice. Only site f1 is an unimproved grassland habitat.

Status of the Heath Fritillary in the forest of Fontainebleau – Proposals for Biological Conservation

Population Dynamics: Heath Fritillary populations are characterised by huge fluctuations in abundance from year to year, except in small colonies (c3 and c4 sites in Chanfroy and in sites in Macherin, where little fluctuation is seen). These fluctuations are most pronounced in woodland biotopes and reflect the rapid change that occurs in the suitability of the habitat for breeding following a clearance (WARREN, 1987b). Populations increase rapidly once an area has been colonised, with numbers reaching a peak 2-3 years after cutting. The case of La Feuillardière does not seem to meet this theory. Most likely the observation of two single specimens is a chance occurrence in an unsuitable habitat.

In less vigorously coppiced woodland and in conifer plantations on former deciduous sites (Chanfroy and Macherin), colonies usually become extinct 7-10 years after clearing. Changes in habitat suitability are usually less sudden and fluctuations are also thought to be related to the weather conditions during the flying period. Warm dry habitats (Macherin and c3, c4 in Chanfroy) show less fluctuation as compared with clearings in sites c1 and, to a lesser extent, in c2 sites in Chanfroy.

The sub-populations fluctuate independently of each other in response to local changes in their habitat (e. g. little fluctuation is observed in c3, c4 as opposed to the larger sub-populations in c1 and c2). The amount of movement between colonies is highly variable but an important factor is clearly the nature of the intervening vegetation. Movement is greatly encouraged by the presence of open, sunny woodland paths (corridors) between the sites. Despite the detection of occasional migration within large woodland complexes (perhaps the case for f1?), there is little or no evidence of movement between adjacent woods. The furthest distance at which a new site has been colonised since the windstorms is 4.5 km away from the nearest colony (in this case, the large colony of Chanfroy). On this basis, the natural colonisation of a site more than 10 km from the nearest colony could take ages.

Proposals for conservation of the Heath Fritillary: The lack of regular woodland management, especially insufficiently frequent coppicing, leads to fewer open habitats within woods and tends to reduce the rate of potential colonisation of new clearings. Afforestation and abandonment by the Office National des Forêts is also a negative factor of colonisation.

The main risks for species maintenance and expansion are:

- Continuing changes in woodland management, together with the limited extent of coppiced area and increased isolation of new clearings in the forest of Fontainebleau.
- Continuing decline in market for coppice produce.
- Long term threat from isolation and fragmentation of habitats and viability of populations.
- Potentially a minor threat from collectors.

Coppice cut in small plots (0.4-2ha) on a rotation of 10-20 years, with plots adjacent to each other within a maximum 3 year interval or within 300m of an existing colony and connected by a network of wide rides/ glades will help to encourage rapid colonisation of new plots. After the beneficial effect of the windstorms Lothar and Martin, it will become urgent to manage the Plaine de Chanfroy and Macherin sites, selectively felling to maintain enough corridors and clearings for population survival and colonisation of suitable habitats (col. pl. 28: 4).

In this case study, new clearings after the storms were rapidly colonised. Indeed it is extremely unlikely that any new clearing that is created more than 1 km from a population would ever be colonised, as the butterfly is unlikely to arrive during the short period that conditions remain suitable for breeding (e. g. what probably happened in La Feuillardière). Therefore in order to survive in a wood, the species requires the regular creation of clearings which are rich in Common Cow-Wheat reasonably close together, and interconnected by a network of wide rides and glades so that colonisation can occur rapidly after clearance. The species will become locally extinct if there is any break in the creation of new clearings, or if the distance between clearings is increased beyond a critical point (c. 300 m).

Coppicing or group felling to produce such clearings is mandatory and continuity of such management is essential: A Plan may need to be put in place to ensure the maintenance/ restoration of coppice management in the existing woodland habitats and maintenance/ restoration of appropriate cutting regimes on existing grassland habitats. Further survey and monitoring work on the existing populations and identifying potential habitat for extending/ reinforcing the Heath Fritillary's range is needed. The Plan must be publicised and funds sought to ensure that the proposed strategy can be accomplished.

Conclusion: L'ANVL (Association des Naturalistes de la Vallée du Loing et du massif de Fontainebleau), a member of the IUCN, proposed to create a National Park in the forest of Fontainebleau. However, as known and recently highlighted by GIBEAUX (1999): « [...] le choix de la structure - Parc national (ou régional) [...] ne me semble pas constituer le fond du problème. L'important, et le seul élément qui me paraisse déterminant, reste que les biocoénoses soient conservées en l'état. » : «

the choice of a status (national, regional Park) is not the key point ; what is important is to protect biotopes... ». Whatever will be the future of the forest of Fontainebleau, we must keep in mind that this place is the most visited one in France with more than twelve million tourists each year (from memory, the Eiffel Tower is visited by 6 million people a year!). Those twelve million people

visiting the forest of Fontainebleau bring with them their pollution and millions of pets (!) and are responsible for much disturbance, resulting in the unwitting destruction of plants and insects. Can we assess so negatively the collecting impact of a butterfly amateur?

This is why we are proposing a Plan to assess and manage the butterfly fauna in the forest of Fontainebleau for a long term conservation plan.

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Colour plate 28/Farbtafel 28

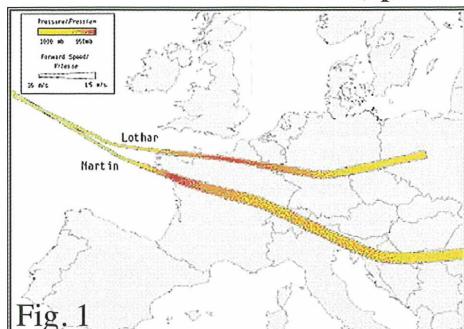


Fig. 1

Figure 1: Tracks of the two windstorms Lothar and Martin showing their increasing intensity while moving overland (from ABRAHAM et al., 2000).

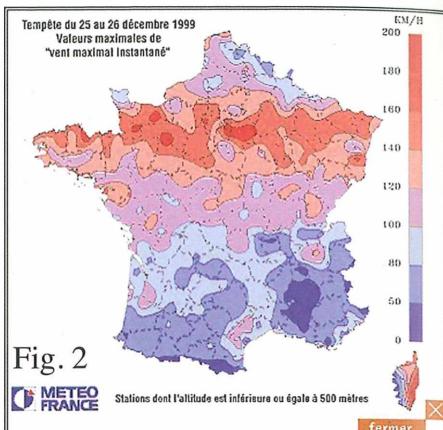


Fig. 2



Stations dont l'altitude est inférieure ou égale à 500 mètres

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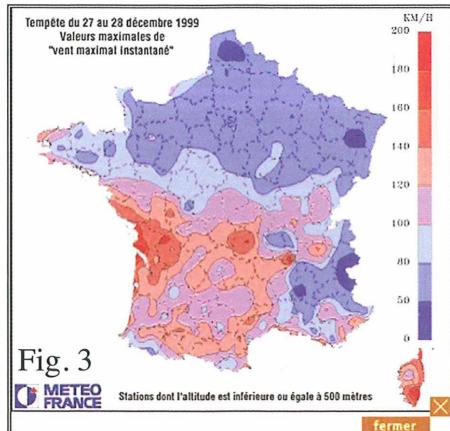


Fig. 3



Stations dont l'altitude est inférieure ou égale à 500 mètres

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